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Science Teaching in Rural India

- An Experiment

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If the teaching of science in our schools, borders on the 'irrelevant' then this is all the more so when we examine science as it is taught in rural India. For science to become meaningful in the lives of rural students the teaching of science needs to be radically changed. It is important to inculcate - in the students - a scientific and rational approach to their environment. PRABUDDHA GANGULI describes an attempt in this direction by a couple of voluntary agencies working in Madhya Pradesh.

The failure of our schools to provide relevant education has long been acknowledged by educationists and laymen. An analysis of the present system indicates that material, curriculum, teaching methods etc., already irrelevant in the urban schools, are even more so when directly transplanted into our rural educational system.

Now, what are the basic problems which make the rural educational requirements so distinct from their urban counterparts? It is well established that more than 90 per cent of the rural children drop off from the formal educational stream by the age of twelve years. After that, they either settle down with some work in their own villages or join the mass exodus to the urban centres in search of menial jobs.

The question that confronts us at this stage is how to reduce this mass exodus? Can the formal years of training be made more meaningful? While answers to these questions are not obvious, they are important because of the vast waste of human potentialities in rural India.

Realising the drawbacks of the present system, Kishore Bharati and Friends Rural Centre, two voluntary organisations in Hoshangabad District (Madhya Pradesh) initiated among many of their projects (which included farming, cattle development and nonformal education), a science teaching programme in 16 existing middle schools of that area.

This article outlines only the Science Teaching Programme and some of its ramifications.

The Programme

One may pose a question: why teach science in villages when there are so many other basic problems? A very valid doubt!

What we believed is that a good and effective training during their early years in the methodology of science would help children to develop their inherent analytical power, their ability to formulate and observe problems, make logical analyses and draw conclusions from their experiences. Coupled with the teaching of science, a training programme which is totally integrated with the environment may help the youth to tap resources in their own areas and contribute to the development of their immediate surroundings instead of joining the aimless flight to urban centres.

Thus, a qualitative knowledge of basic science and a grounding in the scientific method would remain permanent assets, so that even if the student dropped out of school, this training would help him in any profession he chose.

As a result of a proposal put forward by the two voluntary agencies mentioned above, in 1972 the government of Madhya Pradesh initially authorised the two agencies to experiment in sixteen rural middle schools for a period of three years. Nine of these schools are located around the Friends Rural Centre in Hoshangabad Tehsil and seven around Kishore Bharati in Sohagpur Tehsil. A unique feature was the total freedom given to us to experiment with books, syllabi, learning methods, examination systems and to devise teacher training techniques.

A major project like this cannot be executed through meagre and isolated efforts. So, besides the rural school teachers, we were able to bring together a large number of like-minded ‘teachers, students and scientists from various institutions and organisations like The All India Science Teachers’ Association, Physics Study Group, Bombay Municipal Corporation, Gandhi Vidyapeet (Vedchi, Surat District), Lok Bharat (Sonora, Gujarat), The Space Applications Centre (Ahmedabad), Universities of Delhi and Rajasthan, The Tata Institute of Fundamental Research (Bombay) and Indian Institute of Technology (Kanpur) to participate in orientation courses for teachers, monthly follow-up meetings and the development of teaching material.

The Beginning

We realized that there was a severe lack of trained personnel in rural schools to initiate and carry out such a programme. So, in May 1972, a three-week orientation course for 34 teachers from these sixteen schools was arranged. The teachers chosen had little or no background in science and almost all of them were without any university degrees.

During this course, teaching material in physics was tried out and some material in Biology was also developed. The teachers were trained in science teaching methods - namely the “discovery approach”, which would help the children to learn science through experiments, observations and from an analysis of their daily experiences. This approach transforms the role of the teacher from that of a lecturer to that of an observer and guide, who helps children to do simple experiments and to think analytically. Existing books were found to be totally ineffective and hence were dropped from these sixteen schools. They were replaced by a simple workbook and inexpensive kit (developed during the course) which were designed to utilise, as far as possible, the rural environment. The orientation course was followed-up in monthly meetings with the teachers and frequent visits to class rooms to evaluate the effectiveness of the method.

The medium of instruction was Hindi, the local language of the area. It is obvious that this was the most convenient medium of instruction because it helped children to express themselves easily. A brief description of the class room activity will help to illustrate the “discovery method” followed there.

The average strength of the class is about forty students. This class is split into small groups of four students each. In the beginning of the science class, the teacher outlines the concepts that the students are expected to learn on that day. Accordingly, the science kit is distributed to the various groups. The children do not possess any science text book.

Supposing that a set of students are to study the Archimedes Principle, the kit given is a simple tin can with a spout, a set of standard 1cc plastic cubes and a graduated measuring jar. After reading the instruction card, the group proceeds with the experiments. The volume of the cubes is already known since the children have measured their volume geometrically during the measurement lessons. By sinking the cubes one by one, the volume of the water displaced is measured using the graduated measuring jar. The volume of the water displaced by the cubes is compared with the volume of the cubes measured geometrically. Then, through questions posed in the instruction cards and with the help of the teachers, the students are led to discover that the volume of the object sunk is equal to the volume of the water displaced by it.

The teacher has a substantial role to play since his guidance would help children to think coherently and draw the right conclusions from their observations. To help the teacher in this activity, he is supplied with teachers’ guide which outlines the importance, implications and applications of various principles in our daily life. Thus, the children are not only trained to do careful experiments but are encouraged to draw diagrams of their apparatus and if possible, of the complete sequence of the experiment. This helps them to develop a connection between their observations, understanding and expression. Many other such experiments in science have been developed to train the children in the spirit of organised team work and the scientific attitude.

Recent Developments

Since 1972, the programme has come a long way. During the second and third years of the experiment (after two orientation courses in summer) the programme was extended to the 7th and 8th standards and the course was increased in its scope to include subjects like chemistry also. Extensive criticism and feed-back by village school teachers, students and teacher trainers participating in the programme, on the materials and methods developed previously, not only gave us new insights into the problems of designing and implementing the “discovery approach” of teaching science in the rural areas but also led to an overall revision in the content and direction of the programme.

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We also learnt that beliefs, which underlie the everyday actions and attitudes of villagers, profoundly influence the implementation, as well as formulation of the plans for a programme - an important aspect often overlooked. This was particularly felt while introducing biology through the “discovery approach” to this set of teachers, most of whom are staunch vegetarians. How can the child discover the parts of an egg and their development without breaking it? But this is unacceptable to most teachers as they think of it as the destroying of life.

Faced with such problems we had to do some serious thinking and have come up with a method of introducing the subject of Life Sciences with least displeasure to the teachers and students. Fields trips during botany lessons and specimen observation in zoology seem to be a good start for the Life Sciences.

Examination System

It is obvious that such an activity-based science teaching programme would mean little within the conventional examination system. So, we put in a lot of effort, together with the teachers, in developing a relevant evaluation system. The periodical and final examinations have two important parts:

1) a written examination which evaluates the student's independent thinking ability and written expression.

2) an oral in which the student’s ability to communicate and react to new problems based on his previous experiences is gauged.

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Some typical questions from a written and oral examination respectively are presented as representative examples.

In the written part the questions asked are of two types:

1) Questions that evaluate the students’ ability to draw qualitative results and

2) Questions that check their manipulative and quantitative skills

For instance, the children are familiar with chemical reactions of acids and bases with litmus paper or phenolphthalein solution. In the question paper, observations on a set of acids and bases with litmus paper and phenolphthalein solution are presented in a tabular form. The student on the basis of his previous learning is asked to point out which of the observations are false.

At the higher level, i.e. in the 8th standard, among various other questions a few quantitative questions are also included. For example, a map of Madhya Pradesh is given in the question paper with a few towns marked in it. With the help of the given scale the children are asked to estimate the distance between certain towns and find their Cartesian and polar co-ordinates. This question tests the student's skills in measurement, use of rulers, protractors and mathematical manipulations with decimals etc.

The oral examination is conducted individually by the teacher trainers with the help of the teachers. During the biology course the students learn through experiments that plants manufacture starch only in the presence of sunlight. The natural questions that follow this piece of information are: Do plants make starch at night? Do plants utilise the starch? During the oral exams, well-illustrated charts showing experiments (which answer the above questions) are given to the student. Based on similar experiments performed by him during the course, and through leading questions put by the examiner, the children are expected to give answers to the above questions.

Having conducted the examination, the teachers were trained to evaluate the answers and with active help from them, grading procedures were developed. The results, based on the examination of 1700 children, were analysed systematically to find out how much the students had understood and how effective was the programme. To cite an example, we found that children severely lacked in their understanding of the decimal system. Because we were using rupees and paise to explain decimals, even those who understood the method became quite confused when they had to deal with numbers with three or more digits after the decimal point. So, we had to modify our method of teaching decimals and develop some teaching aids. The results of the detailed analysis help considerably to restructure the science teaching programme.

Criticisms

The most frequent criticisms of such a teaching method can be summarised as follows:

1) It is a slow and "luxurious" process.

2) There is a great danger that the students may not acquire a whole body of necessary facts.

3) Children receiving such training at the middle school level cannot fit in with the conventional stream at the high school level.

4) Such a programme cannot expand without considerable dilution in quality.

A very careful comparative study of the conventional science courses being taught in the middle schools in Madhya Pradesh and the syllabus developed for this programme indicates that the two are quite similar in terms of their total content. Certain topics which were thought to be either too heavy for middle school students or too urban-based or which were in any case to be taught in great detail at the higher level, were dropped from the programme.

One such topic is the concept of atoms and molecules. We feel that a child of 10 years is probably too young to appreciate the concept of atoms since the logical transition from the macroscopic to the microscopic world is not qualitative and obvious. One has to first learn to appreciate the involved concepts of the laws of definite and multiple proportions. This would require careful experiments with balances and volumetric measurements. Serious attempts are being made to devise semi-quantitative experiments which would help the student to conclude intuitively that there are basic building blocks like atoms and molecules.

A purely academic study of science has been replaced by the study of environment-oriented subjects like astronomy (where children learn about the movement of stars, planets, eclipses etc., through simple experiments), biology (where they measure the growth rate of seedlings) and chemistry (where they measure the saturation limit of various soil samples).

Since learning is a non-linear process, students can at a later stage make up for facts and details they missed in the early part of their education. Though this method is slow, it is deep rooted and gives the child the confidence and the ability to make careful observations of the world around him.

The kit, which has been developed for a total of 120 students in the 6th, 7th and 8th standards of a middle school, utilises things of everyday usage and costs only about seven hundred rupees. An attempt is being made to reduce the cost of the kit by developing a course which would utilise more of the existing village environment.

The Science Teaching Programme is now in its fourth year. The first batch of students (who have participated in this programme for the last three years) have just joined high school. A close contact is being maintained with these students to estimate the problems of a transition from such an activity-based science teaching programme to the conventional stream at high school. Though no concrete data is available as yet, we expect that these students will not find the transition too difficult, being equipped as they are with a logical and analytical approach to their work and their environment.

Impact on Teachers and Students

As I have pointed out before, one of the significant features of the programme is the active participation of the 34 school teachers in restructuring, designing and scheduling their own syllabus, within the “discovery approach” with only occasional help from the teacher trainers. In January 1974, the teachers, with the help of their students, organised a Science Exhibition in their villages. In this exhibition, children presented some of their working models and experiments illustrating simple but significant concepts in science which they had picked up during their course. Not only did this make a profound impression on them, but it also had an encouraging effect on the total village community.

Whether or not the science teaching programme is realistic is a question that will be answered only if the programme spreads easily without dilution or loss of quality. An attempt is now being, made to expand the programme and the long-range goal is to build from amongst the teachers involved, a set of teacher trainers, so that a local multiplier effect is generated. Initial steps in this direction have shown encouraging results. In June 1975, this set of village teachers, on invitation from the Regional College of Education, Bhopal, west there to demonstrate the “discovery approach” at a summer school held for teacher trainers in Bhopal. With the confidence now built in them, these teachers feel that this method should be extended to cover other subjects. In October 1975 an orientation course of two weeks duration was arranged for a fresh batch of village teachers in which the trained set of teachers participated as teacher trainers. This experience will help in formulating further plans to extend the science teaching programme. The government of Madhya Pradesh has now granted permission to carry on the experiment for at least another two years.

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Participation of the Academic Community

As pointed out earlier, a large number of scientists, teachers and students from all over the country have been participating in this programme for the last four years. An encouraging feature has been the support it has received from the University Grants Commission (UGC) since 1973. The UGC helped Delhi University to send two of its faculty members to participate on a rotational basis (for a continuous period of 6 months each) to Hoshangabad District. This facility has not only increased the participation of the staff and students of Delhi University and helped them to form a cell in the university campus for the past three years, but has motivated them to take a leading role in the programme. Thus about twenty people from Delhi University, eight young scientists from the Tata Institute of Fundamental Research, Bombay, and one from Indian Institute of Technology, Kanpur, by constant association with the programme and periodic examination of their own success and failure, have now broadened their perspectives and seek creative solutions of their own in facing the challenging problem of rural education. During the last eight months some faculty members from the Holkar College of Science at Indore have also been involved. Of course, much remains to be done, and as more members of the academic community get involved in such a programme, it gains confidence and slowly moves a few steps further towards the set goal.

How Do We Increase Participation?

An experiment of this sort conclusively demonstrates that a meaningful urban-rural interaction can be developed. Unfortunately, the stifling bureaucracies in our institutions do not give enough freedom to young students, teachers and scientists to participate in any rural development programmes. With the various minor modifications that have occurred in the policy of the government, organisations like the CSIR, NCERT, UGC and our elite institutions and universities, one can utilize a large amount of untapped and dormant talent in active development work. This can be done by officially releasing personnel for short durations of time to stay with working rural organisations, get acquainted with their problems and seek possible solutions.

In a developing environment, further progress in these directions undoubtedly requires much more experimentation and innovation by many such voluntary organisations in different parts of the country. No general formulae exist that can automatically be applied without considerable adjustment to suit an area. For any working voluntary organization, suitable manpower is always the greatest obstacle. We have over 2000 major institutions in the country. If some of the institutions get together and adopt an area for development work with some working voluntary organisations, many such small groups can be formed all over the country. By proper coordination among such groups one can derive strength and benefit from mutual experiences.

This sort of participation from the complete spectrum of the professional and academic community will not only increase the consciousness among the young students, teachers and scientists but may even reduce the shocking lacunae that exist in the social content of our formal education in universities and elite institutions.